

Smart Networked Elements in Support of ISHM

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Abstract (500 words or less)

At the core of ISHM is the ability to extract information and knowledge from raw data. Conventional data acquisition systems sample and convert physical measurements to engineering units, which higher-level systems use to derive health and information about processes and systems. Although health management is essential at the top level, there are considerable advantages to implementing health-related functions at the sensor level. The distribution of processing to lower levels reduces bandwidth requirements, enhances data fusion, and improves the resolution for detection and isolation of failures in a system, subsystem, component, or process. The Smart Networked Element (SNE) has been developed to implement intelligent functions and algorithms at the sensor level in support of ISHM.

The SNE consists of three functional layers: 1) power and communication, 2) digital signal processing and intelligent algorithms, and 3) analog signal conditioning and conversion. Each layer is implemented on a separate printed circuit board with standardized interfaces so SNE modules can be tailored to meet the application-specific requirements.

The power and communication layer includes power circuitry that converts Power over Ethernet (PoE) or external DC power to the voltage levels required by the SNE. The power and communication layer enables the SNE to be networked using standard communication protocols such as RS-232 and TCP/IP over Ethernet. With the addition of COTS products, the range of communication protocols can be expanded to common interfaces like ControlNet, Ethernet/IP, and Profibus. The power and communication layer contains network configuration information, enabling plug-and-play of the SNE. The SNE's power and communication layer functions as a Network Capable Application Processor (NCAP), per IEEE 1451.1 Smart Transducer Standard, and enables communication with other IEEE 1451.1-compliant devices. The SNE's NCAP also has the capability to store Transducer Electronic Data Sheets (TEDS) and to timestamp data using an on-board real time clock synchronized using IEEE 1588 Precision Time Protocol (PTP).

The digital signal processing and intelligent algorithms layer is responsible for acquiring and processing sampled data from the analog signal conditioning and conversion layer. The digital signal processor (DSP) performs digital filtering of the sampled data and can be programmed with intelligent algorithms to extract features and detect anomalies. The

intelligent algorithms are tailored for the SNE's specific application and may consist of threshold detection, state identification, spectral analysis, statistical information and confidence intervals, measurement tolerance, multi-sensor array algorithms, etc. The DSP also monitors the SNE's electronics to identify internal hardware failures. It then reports the engineering data and health of the data and electronics to the power and communication layer for distribution over the network.

The analog signal conditioning and conversion layer provides excitation, signal conditioning, and multi channel analog-to-digital conversion. This layer is application-specific and uses redundancy coupled with a unique architecture to assist in fault detection, isolation, and recovery. The hardware can be adapted based on the type and range of the analog signals.

The SNE provides a powerful, modular and flexible architecture for performing health management at the sensor level.

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
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1. REPORT DATE (DD-MM-YYYY)		2. REPORT TYPE Conference Paper Abstract		3. DATES COVERED (From - To)	
4. TITLE AND SUBTITLE Smart Networked Elements in Support of ISHM				5a. CONTRACT NUMBER NAS10-03006	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
				5d. PROJECT NUMBER	
6. AUTHOR(S) a. Rebecca Oostdyk, ASRC Aerospace; M/S: ASRC-25, Kennedy Space Center, FL 32899 b. Dr. Carlos Mata, ASRC Aerospace, M/S: ASRC-25, Kennedy Space Center, FL 32899 c. Jose M. Perotti, NSM/S: KT-C, Kennedy Space NASA-Kennedy Space Center, FL 32899				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) ASRC Aerospace Kennedy Space Center, NASA				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Jose M. Perotti, M/S: KT-C, Kennedy Space NASA Kennedy Space Center, FL 32899				10. SPONSOR/MONITOR'S ACRONYM(S) NASA KSC	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT At the core of ISHM is the ability to extract information and knowledge from raw data. Conventional data acquisition systems sample and convert physical measurements to engineering units, which higher-level systems use to derive health and information about processes and systems. Although health management is essential at the top level, there are considerable advantages to implementing health-related functions at the sensor level. The distribution of processing to lower levels reduces bandwidth requirements, enhances data fusion, and improves the resolution for detection and isolation of failures in a system, subsystem, component, or process. The Smart Networked Element (SNE) has been developed to implement intelligent functions and algorithms at the sensor level in support of ISHM.					
15. SUBJECT TERMS smart networked elements, ISHM, data fusion, SNE, TCP/IP, Ethernet, ControlNet, Ethernet/IP, Profibus, Transducer Electronic Data Sheets					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES 2	19a. NAME OF RESPONSIBLE PERSON Rebecca Oostdyk
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER (Include area code) (321) 867-5637